“GLOBALIZING THE SCIENCE CLASSROOM”

Exploring the development of students’ conceptual understanding of climate change from international peer collaboration

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Forord

For fire år siden startet jeg doktorgradstudiet ved Institutt for lærerutdanning og skoleforskning (ILS) ved Universitetet i Oslo. Jeg var full av forventning og så fram imot å fordype meg i naturfagdidaktikkens akademiske verden. Som biolog og lærer så jeg fram imot at få bedre kunnskap om hvordan elever lærer og hvordan best formidle faget mitt.

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Majken Korsager

Oslo, 18. desember 2012

Abstract

Climate change is not local, it is global. This means that many environmental issues related to climate change are not geographically limited and hence concern humans in more than one location. There is a growing body of research indicating that today's increased climate change is caused by human activities and our modern lifestyle. Consequently, climate change awareness and attention from the entire world's population needs to be a global priority and we need to work collaboratively to attain a sustainable future. A powerful tool in this process is to develop understanding of climate change through education. Recognizing this, climate change has been included in many science curricula as a part of science education in school. However, teaching a complex and global topic as climate change is not easy. The research in this thesis has been driven by this challenge.

The aim of the study is to understand the development of students' conceptual understanding of climate change from international peer collaboration. The research has used both quantitative and qualitative methods, through analyses of questionnaires, interviews and student text responses from 157 secondary students (age 16-19) from Canada (n=30), China (n=46), Sweden (n=52) and Norway (n=29). These students were engaged for six weeks in an inquiry-based science module, Global Climate Exchange, which was developed for this study. In addition an assessment tool, the Ecological Understanding Tool, was developed to enable tracing the development of students' conceptual ecological understanding.

The results from the studies in this thesis show that giving students opportunities to collaborate with international peers can be productive for them to develop a coherent understanding of the complexity of global climate change. The results also show that one way to allow and support this development is to implement an inquiry-based science module like Global Climate Exchange, and the Ecological Understanding Tool can be applied to assess this development.

The findings are valuable for development of secondary science education, in particular when teaching global and complex topics, like climate change. Additionally, the development of the assessment tool is a valuable contribution for analytic work in science education research.

This dissertation is a contribution to the field of science education research. The work has been conducted from 2008 to 2012, at the Department of Teacher Training and School Research, Faculty of Educational Sciences, University of Oslo.

TABLE OF CONTENTS

1 INTRODUCTION

During the recent decade, global climate change has received increased attention as it has adverse impact on the environment, which in turn generates concerns on both social and economic levels. As a result, climate change is acknowledged as one of the greatest challenges of our time.

The climate system is a global, complex, interactive system consisting of interactions between five major components: the atmosphere, land surface, snow and ice, oceans and other bodies of water and living organisms (IPCC, 2007b). Because the climate system is a global system, it has no geographical boundaries. Hence, when climate change affects the atmosphere and causes environmental issues, these issues are global. These issues differ from many environmental issues we have faced in the past, which have often been limited to local or regional ecosystems.

It is challenging to explain global climate change issues. One challenge is their complexity which makes them difficult to predict, explain and solve. This complexity might be one reason for the mixed message often presented in media. Further it might explain why it is challenging to understand this topic (Daniel, Stanisstreet, & Boyes, 2004; Dove, 1996; Gowda, Fox, & Magelky, 1997; Papadimitriou, 2004; Rye, Rubba, & Wiesenmayer, 1997). Another challenge is that the entire world's population, to various degrees, is both impacted by and contributing to climate change. This makes climate change a topic which is socially relevant to all of us. Climate change is included within the category socio-scientific issues (Sadler, 2009). These are scientific issues which have social factors embedded within the way society must deal with them (Kolstø, 2000) .

Climate change is not new; over time the Earth's climate is continuously changing. However, observations during the last decades show an acceleration and magnification of climate changes that has not been experienced in the past (Le Treut et al., 2007). Furthermore, there is a growing body of research indicating that the recent climate changes are caused by human activities and our modern lifestyle (IPCC, 2007a; Rosenzweig et al., 2008). This reality creates a need for educating the world's population to understand climate change so that we can work on global solutions.

During the last decade, several attempts have been made to introduce climate change as a topic in science education. Education may not only increase students' awareness, it could also give students the knowledge and competences they need to make informed personal decisions for a sustainable future (Kolstø, 2000). However, research indicates that climate change is a particularly challenging topic for many students (Cordero, Todd, & Abellera, 2008; Gowda et al., 1997; Liu & Hmelo-Silver, 2009; Mohan, Chen, & Anderson, 2009). One reason for the lack of understanding of the topic could be, as emphasised by several researchers, the way climate change is taught (Dove, 1996; Moser & Dilling, 2004; Rebich & Gautier, 2005), often with a standard lecture format with limited student engagement that does not necessarily encourage student understanding.

Studies have shown that one approach which has been effective in developing students' conceptual understanding of complex science topics is peer collaboration through inquiry-based science teaching (R. D. Anderson, 2002; Gerard, Spitulnik, & Linn, 2010; Lee, Linn, Varma, & Liu, 2010; Minner, Levy, & Century, 2010; Slotta & Linn, 2009). Inquiry-based science teaching engages students in a process of activities such as diagnosing problems, identifying questions, searching for information, collecting evidence, planning investigations, researching conjectures, interpreting evidence, formulating explanations, communicating findings, debating with peers and forming coherent arguments (Lee et al., 2010). Such inquiry activities appear to be successful because they fulfil three fundamental and well-establish principles of learning: engaging students' prior understanding, developing students' competence in an area of inquiry and helping students to gain a metacognitive approach to their own learning (National Research Council, 2005, pp. 1 - 12). Furthermore, emphasizing peer collaboration in inquiry-based science teaching can support the development of students' conceptual understanding. Peer collaboration can give students access to a greater diversity of ideas and perspectives and hence stimulate students' individual reflection (Fawcett & Garton, 2005; Gerard, Tate, Chiu, Corliss, & Linn, 2009; Hoadley, 2000, 2004; Tao, 1999).Yet, peer collaboration seems to be most successful when students experience discrepancy, which is most likely to occur when they interact with peers with unequal competences or different knowledge bases (ibid.; Driver, Asoko, Leach, Mortimer, & Scott, 1994). In such interactions students might experience cognitive conflicts which force them to reflect upon their own understanding, and either reinforce, revise or extend it by building connections between old and new knowledge (Slotta & Linn, 2009).

By connecting students with peers across borders, and engaging them in international peer collaboration, the students can contribute with different knowledge due to their cultural and geographic differences (Slotta & Jorde, 2010). A benefit of international peer collaboration is thereby that students get access to a greater diversity of ideas and global perspectives on science issues than when the interactions are limited to national or local peers. This could be valuable when students are learning about a global topic such as climate change, because this may help them to acknowledge the global aspects of the issues and perhaps grasp the causal complexity. Hence international peer collaboration may be a way to "globalize the science classroom" and support the development of students' conceptual understanding of climate change.

1.1 Aims

Based on research and theories of learning, international peer collaboration seems to have great potential for positive impact on the development of students' conceptual understanding in science, even though the number of such studies is limited. Recognizing the significant importance of educating students to understand climate change issues and the opportunities of international peer collaboration, the overarching focus of the research reported in this thesis is:

> *To explore the development of students' conceptual understanding of climate change from international peer collaboration.*

The thesis has several objectives. First, one aim is to make a methodological contribution to the field of assessment in science education by analytically focusing on development of students' ecological conceptual understanding. A second objective is to explore the potential of international peer collaboration in science teaching.

1.2 Outline of the thesis

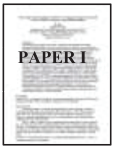
This thesis consists of an extended abstract and three Papers. The extended abstract includes five chapters: *Introduction, Theoretical background, Methods, Summary of results*, and *General discussion.* The purpose of the extended abstract is twofold. Firstly, it aims to justify the theoretical and empirical choices I have made during in my PhD-study. Secondly, it aims to explain the background for the three Papers and how these Papers contribute to addressing the overarching research focus in the thesis.

After this *Introduction,* comes *Theoretical background* where the science of climate change is explained. This serves as a background for why it is essential, but also challenging to understand this science. Conceptual understanding of climate change is defined and connected to environmental education and the literature on inquiry and peer collaboration in science education is reviewed.

In the *Method* chapter I first clarify the empirical setting for the research by describing the science module Global Climate Exchange. The second section of the chapter is a description of the collection and selection of data, and the analytic methods used in each Paper. To conclude the method chapter, research credibility - including validity, reliability and generalization - is discussed.

The main findings from the three research Papers in this thesis are presented in S*ummary of results*.

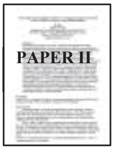
General discussion is the last chapter of the thesis. In this chapter the results from the three Papers are connected to the overarching research focus, and implication of the contributions of this research for science teaching are discussed. The three Papers follow the general discussion as described below:



Korsager, M. (2012). The Ecological Understanding Tool (ECUT): Assessing General and Subject Specific Aspects of Students' Ecological Conceptual Understanding. *Manuscript submitted 20.07.12 to IJESE - International Journal of Environmental and Science Education.*

Research questions:

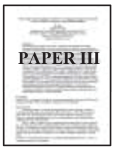
- *How can students' ecological conceptual understanding be defined and assessed?*
- *How can the development of students' ecological conceptual understanding be evaluated?*



Korsager, M., & Slotta, J. D. (2012). "Climate change is global, not local" – A study of the Development of Students' Ecological and Global Understanding of Climate Change. *Manuscript submitted 02.07.12 to IJESE - International Journal of Environmental and Science Education.*

Research questions:

- *What is the impact of Global Climate Exchange on Norwegian upper secondary students' ecological and global conceptual understanding of climate change?*
- *Are there any patterns in students' international collaboration activities that correlate with their ecological and global conceptual understanding of climate change?*



Korsager, M., Slotta, J. D. & Jorde, D. (2012). Global Climate Exchange – Peer Collaboration in a "Global Classroom". *Manuscript submitted 21.12.12 to NorDiNa – Nordic Studies in Science Education.*

Research question:

- *How does "Global Climate Exchange" allow students to cooperate and collaborate, and how do these collaborations promote learning?*

The figure on the next page (Figure **1**) provides an overview of the background for my research, the main focus of each of the three Papers and how each relates to the goal of my research.

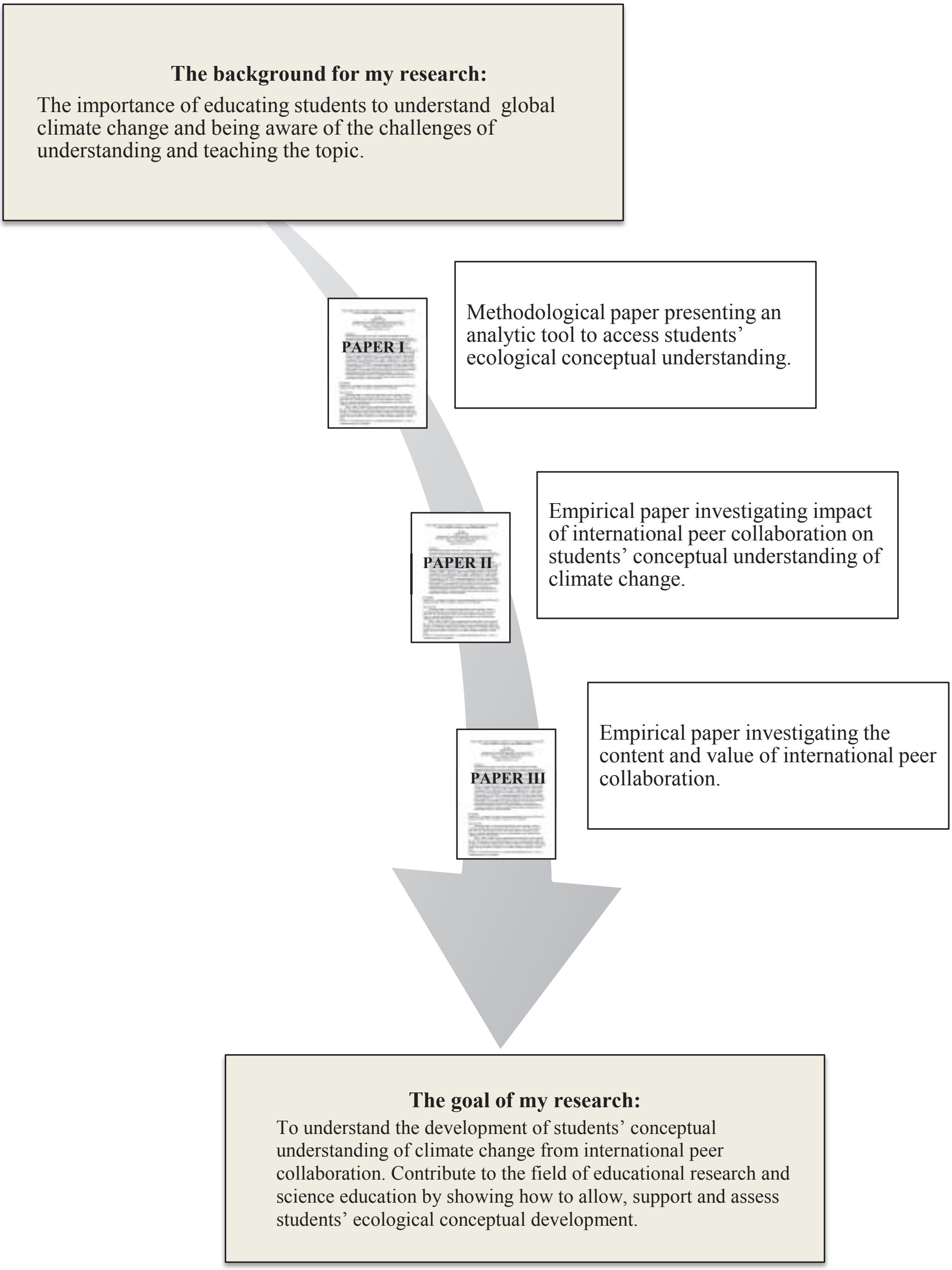


Figure 1: An illustration of the background for my research, the main focus of each of the three Papers and how each relates to the goal of my research.

2 THEORETICAL BACKGROUND

This chapter first briefly explains the scientific background for climate change (section 2.1), which is followed by a description and explanation of the challenges of students' conceptual understanding of the topic (section 2.2). The intention is to give the necessary overview to comprehend why the topic is emphasized in environmental education and why it is a challenge to teach. Section 2.3 gives an overview of existing national efforts taken to support teachers when teaching environmental education. Finally, a review of what research says about inquiry in science education is given in section 2.4, and a review of peer collaboration in inquiry-based science teaching with arguments for how this might be an effective approach to teach about climate change is given in section 2.5.

2.1 The science of climate change

The concept climate refers to long-term average weather (from months to millions of years), including the mean and variability of abiotic factors as temperature, precipitation and wind (IPCC, 2007b). The Earth's climate is powered by solar radiation. Any changes in the radiation balance on the Earth causes, through a variety of feedback mechanisms, the climate to change either as a direct as or as an indirect response (Le Treut et al., 2007). The visible evidence of climate change is a significant change of one or several of the abiotic factors in the climate system (e.g. temperature, precipitation and wind).

When changes occur in the climate system, several feedback mechanisms are involved, some of which can amplify climate change. An example of this is the "ice-albedo feedback", when a raised concentration of greenhouse gases causes global warming and leads to increased melting of snow and ice. The result is darker land and water surfaces which absorb more of the sun's radiation and hence cause an increased global warming. This creates a reinforcing feedback loop. Other feedback mechanisms can diminish the effects of a change, and hence decrease climate change. Some processes include both amplifying and diminishing feedback mechanisms. One such process involves aerosols because they interact both directly and indirectly with Earth's radiation budget and climate. Sulfate aerosols, from burning coal, biomass and volcanic eruptions, tend, to cool the Earth by directly reflecting some of the incoming solar radiation away from the Earth. Whereas other kinds of particles, such as black carbon aerosols (similar to the soot in a chimney) absorb sunlight and have the opposite effect on the climate (NASA, 2012). These examples of mechanisms and processes illustrate some of the complexity in the climate system.

Climate change is nothing new; climate on the Earth has always been changing under the influence of its own internal dynamics and because of natural external factors due to natural variability. Some of the natural variability, such as fluctuations in temperature, may also be caused by the solar cycle variation in irradiance (Lean, 2009). Natural variability normally takes place over longer time scales causing ecosystems in the biosphere to change. Species living in a changing ecosystem will either adapt (evolve) to the new environment, move or die out (Begon, Harper, & Townsend, 1996; Campbell, Reece, & Mitchell, 1999). This dynamic change is a regular process in nature.

However, climate observations during the last decades display an acceleration and magnification of climate changes such as increase in average global air and ocean temperatures, widespread melting of snow and ice and rising average global sea levels (IPCC, 2007a). The Intergovernmental Panel on Climate Change (IPCC), established in 1988, reviews and assesses the most recent scientific, technical and socio-economic information produced by scientists worldwide about climate change. Until today IPCC has published four assessment synthesis reports in 1990, 1995, 2001 and 2007, and the conclusion is clear: warming of the climate system is unequivocal and it appears to be difficult to explain todays' increased climate change by natural variability (IPCC, 2007b; Powell, 2012).

Results from climate simulations estimate the sum of solar and volcanic forcings during the past 50 years. According to these simulations, the natural change should have been a global cooling, not a global warming. In addition, there is an increasing amount of evidence of anthropogenic influences on climate change that correlates to our modern lifestyle. For example, due to human activities, global greenhouse gases (GHGs) emissions have increased by 70% between 1970 and 2004, and this is considered as one of the major causes to climate change. This is the reality and this is the reason why climate change needs attention from the entire human population on Earth.

When climate change is presented in the media, it is often presented as a controversial issue. Even though scientists are still debating the issues, there is a consensus among scientists

(IPCC, 2007a; Oreskes, 2004; Powell, 2012) that human activities contribute to climate change. The current debates are more about understanding the complexity in climate change aiming to make more accurate estimations of climate change issues rather than a discussion about whether humans activities have an impact or not. Recent scientific debates have had their origin in the use of simple conceptual models, which could not comprise the complexity of the climate system (Nikulin, Kjellström, Hansson, Strandberg, & Ullerstig, 2010). Todays' models are considerably improved, but far from perfect. It is still a major scientific challenge to estimate climate changes and explain correlations between all the mechanisms involved in the climate system (Schenkel, 2010). This is the main reason for the continuous scientific debate and hence for the media's presentations of climate change as a controversial issue.

2.2 Conceptual understanding of climate change

Climate change is one of the greatest challenges of our time, as it has effects in possible permanent adverse ways on ecological, social and economic levels. Due to the fact that the climate system is global, climate change issues are socially relevant to the entire world's population. However, as described in the previous section, climate change is complex. Processes and mechanisms in the climate system are inter-correlated in such ways that even though scientific knowledge has increased immensely the last decades, much of this knowledge still contains elements that are uncertain and tentative (IPCC, 2007b; NASA, 2012). Consequently, a comprehensive understanding of climate change is more than about finding "correct" answers. It is about trying to grasp relations and correlations between climate, change and issues, and it is a way to develop comprehensive understanding by focusing on causalities.

Causalities refer to patterns of interaction between causes and effects (Grotzer & Perkins, 2000; Perkins & Grotzer, 2005) which are central in explaining how the climate system works, and how changes might impact the system. Understanding causalities of climate change can be divided into *ecological understanding* and *global understanding*. *Ecological understanding* refers to the ability to understand the relationship (local and regional patterns of interaction) between biotic and abiotic factors in ecosystems and hence comprehend causal links of concepts in ecosystems (Begon et al., 1996; Campbell et al., 1999). *Global understanding* refers to the ability to identify cause-effect patterns over long distances, considering the Earth ecosystem as a whole and perceive how climate change is affecting the entire globe (NASA, 2012).

A limited understanding of causalities inhibits a coherent understanding of ecological systems (Grotzer & Basca, 2003) and hence the understanding of climate change (Groves & Pugh, 2002). Limited understanding is when e.g. "multiplexed" accounts of cause and effect are neglected and one assumes a cause to be necessary for a particular effect, when in reality the cause may only be "sufficient". Sufficiency in this context, means that if one factor can cause an effect, then a number of other factors can also cause the same effect (multiple causes) (ibid.). This lacking conception often results in a failure to understand the more complex and subtle causal relationships leading to unanticipated effects occurring. In contrast, on a higher conceptual level, a student might understand complex causalities such as recognizing that there are more than one cause to an effect and more effects from one cause. These students can explain *mutually causal connections,* which are complex causalities made up of multiple linear patterns including both indirect effects, and cascading effect patterns, in which causes can be seen as effects and effects as causes.

However, conceptual understanding of climate change is not limited to causalities. It also relates to the understanding of structural complexity. This is referred to as *Organization* and states how information and concepts are organized in an explanation (Biggs & Collis, 1982). At a low level of organization, information is scattered and unorganized, or simply irrelevant to the issue or phenomena under consideration. At a high level of organization, information is well organized and the student forms a coherent explanation of an issue or phenomena.

In brief, the complexity of understanding increases on a scale where organization, information and concepts become more organized; links between concepts are then of higher quality and relevant for the issue or phenomena explained. An analytical focus on students' ecological conceptual understanding is further described in Paper I. Analyses of students' *ecological* and *global conceptual understanding* are described and exemplified in Paper II.

Not only are causalities in the climate system complex, in addition they are often difficult to estimate. It is not surprising that research reveals that many teachers, students and people in general struggle to understand concepts related to climate change (Daniel et al., 2004; Dove, 1996; Ekborg, 2003; Ekborg & Areskoug, 2006; Papadimitriou, 2004; Rye et al., 1997). Papadimitriou (ibid.) points to that climate change is often taught using a standard lecture format with limited student engagement, and concludes that teaching the topic this way might contribute to students' limited understanding of climate change.

2.3 Environmental education in science

Education for sustainable development often involves issues which embrace three main dimensions: social environment, natural environment and economy, which are seen together in a holistic context. This differs slightly from environmental education where the emphasis is on the natural environment, and to a lower extent, the social environment and economy. Socio-scientific issues, such as global climate change, are excellent starting points for connecting the social and political dimensions of environmental issues along with the underlying science. Because they represent real world issues that are personally meaningful to students, socio-scientific issues hence present important contexts for learning science (Sadler & Klosterman, 2009; Zeidler & Nichols, 2009).

In Norway science is an obligatory subject from grades 1 to 11[1]. In upper secondary school (grade 11) is environmental education mainly covered within science in a subject area called "sustainable development" (Utdanningsdirektoratet, 2006). The main focus in "sustainable development" is described in the curriculum as *"development of knowledge on and respect for the diversity of nature* including *focus on the requirements for sustainable development, the place of man in nature, and how human activities have changed and continue to change the natural environment locally and globally"* (ibid. p. 2).

Even though "climate change" is not explicitly mentioned in the science curriculum for grade 11, several of the competence aims are related to the topic such as: *select and describe some global conflicts of interest and assess the consequences these might have for the local population and the global community; elaborate on how the international community is working on global environmental challenges.* There are in addition competence aims directly related to climate change in the subject area "radiation and radioactivity": *explain what the greenhouse effect is and elaborate on and analyse how human activities are altering the energy balance of the atmosphere, and elaborate on some possible*

[1] Overview of the educational system in Norway: http://www.udir.no/Upload/Brosjyrer/5/Education_in_Norway.pdf?epslanguage=no

consequences of the increased greenhouse effect, including in Arctic areas, and the measures that are being initiated internationally to reduce the increase in the greenhouse effect (ibid. p. 8-9.).

These subject areas (sustainable development and radiation and radioactivity) also creates great opportunities to address many of the "basic skills" (reading, writing, numeracy, oral skills and ICT skills), which are integrated in the competence aims. Some of these are that students shall be able: *to formulate questions and hypotheses and to use natural science terms and concepts, argue for one's own assessments and give constructive feedback, collect information, interpret and reflect on the content of natural science texts.* Digital communication systems are also mentioned as an important tool to make it possible to discuss natural science problems and research questions (ibid. p. 3).

To support teachers when teaching environmental education, the Norwegian Ministry of Education and Research has developed a national strategy (Kunnskapsdepartementet, 2012), which describes opportunities, challenges and content of Education for sustainable development. Other national efforts aiming to support teaching of environmental issues, are the development of a number of educational projects (e.g. Den naturlige skolesekken[2], Miljølære[3]). A general evaluation of these projects concludes that they have a potential as educational tools, nevertheless they are only utilized to a small extent by the teachers. The teachers report that they lack competences to implement the projects (ibid.).

To meet some of the challenges in climate change teaching, Schreiner, Henriksen, & Hansen (2005) suggest some possible ways forward for what they call climate education for empowerment. They assume that in order to be empowered to meet the climate issue, a person must be motivated for action and have sufficient knowledge about the science of climate change. Their suggestions include that students should have a general understanding of the global energy flow and about feedback mechanisms, to illustrate the complexity of the system. They (ibid.) call for teaching suggestions «aimed at fostering young people's abilities to relate to the complexities of the climate issue, to see where and how they may influence climate development, and to make decisions regarding this».

[2] http://www.natursekken.no/
[3] http://miljolare.no/

2.4 Inquiry in science education

Nature of Science (NOS) refers to the way we describe how we look at the world (R. L. Bell & Lederman, 2003; Moore, 1993) and includes the foundation of scientific inquiry. Nature of Science is not so much defined by a concise statement, but rather defined more by its components which include: to understand that scientific knowledge is tentative (subject to change), empirically based (based on and/or derived from observations of natural world), subjective (influenced by scientists' background and experiences), partly the product of human imagination and creativity (involves invention of explanations), socially and culturally embedded, the distinctions between observations and inferences (scientific knowledge is partly a function of each) and the relationships between scientific theories and laws (NRC, 1996).

When working scientifically, inquiry is the process of asking questions, formulating hypothesis, investigating and drawing conclusions (ibid.; Schwartz, Lederman, & Crawford, 2004). Scientific inquiry can hence be understood as the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from this work. Subsequently, working scientifically is not *a* method or *a set of* activities; it is an iterative process of seeking information where conceptual understanding ascends from active construction of knowledge.

Reviewing literature in science education research reveals that the word "inquiry" is frequently used in combination with teaching and learning. During such review, it becomes clear that inquiry often refers to a rather wide range of different aspects (R. D. Anderson, 2002; Kirschner, Sweller, & Clark, 2006; Minner et al., 2010; Rakow, 1986). The diversity of definitions and meanings mirror the many characteristics and outcomes of inquiry, and typically characterizes students' activities in inquiry-based teaching and learning, and/or intended learning outcomes from inquiry-based teaching and learning.

When used to describe students' activities these include elements from working scientifically, such as diagnosing problems, identifying questions, searching for information, collecting evidence, planning investigations, researching conjectures, interpreting evidence, formulating explanations, communicating findings, debating with peers and forming coherent arguments (Lee et al., 2010). Some describe practical elements such as laboratory work and fieldwork as requirements for using the definition inquiry-based teaching and learning. However, there is a growing trend of less focus on practical elements and more focus towards training cognitive skills (Duschl & Grandy, 2008) through, for example argumentation and decision-making (Erduran & Jiménez-Aleixandre, 2007; Kolstø & Ratcliffe, 2007).

This is a shift from a content/process focus to an evidence/explanation focus. In addition to describing students' activities, inquiry is also frequently used to define inquiry-based teaching by the degree of scaffolding or teacher guidance. It might then be understood as scaffolded instruction where the teacher is a guide rather than a transmitter (Hmelo-Silver, Duncan, & Chinn, 2007), to unguided instruction where the teacher is almost absent in the student learning process (i.e. inquiry is equal to unguided instruction) (Kirschner et al., 2006).

In studies of impact from inquiry-based teaching and learning, intended learning outcomes are sometimes associated with understanding of scientific processes and other times with conceptual understanding. When associated with understanding scientific processes focus is on making students understand the nature of science and how scientists works (Schwartz, Lederman, & Crawford, 2004). When the intended learning outcomes are conceptual understanding, focus is more on understanding a specific science topic (Muukkonen, Hakkarainen, & Lakkala, 1999; Zacharia & Anderson, 2003).

Many of these diverse definitions are not necessarily contradictions, e.g. laboratory work can be effective with different degrees of teacher guidance, and argumentation might lead to understanding of both scientific processes *and* conceptual understanding of the topic.

Reviews of inquiry-based science learning conclude that this approach in general has a positive impact on developing diverse competences in students such as: scientific literacy, understanding science processes, vocabulary knowledge, conceptual understanding, critical thinking and attitudes toward science and greater student motivation (R. D. Anderson, 2002; Minner et al., 2010). But when inquiry is equated with unguided instruction, the conclusion is that inquiry does not work due to lack of expert–novice differences and cognitive overload (Kirschner et al., 2006). The inconsistent use of the concept inquiry is a dilemma, because when it is not explicitly explained it can be confusing as to what it refers to. This is most likely the reason that research also shows an uneven impact of inquiry-based instruction (R. D. Anderson, 2002; Minner et al., 2010; Windschitl, 1998).

In my work, students engage in inquiry activities with focus on communication with peers (and not on practical work) and where the aim is to develop their conceptual understanding of the topic, climate change. The main focus is on how inquiry activities impact on students' conceptual understanding of science (focus on content) and less explicit (though not absent) on their understanding of scientific processes. I have chosen this focus for pragmatic reasons to limit my study, and not because I perceive students' understanding of scientific processes less relevant.

An inquiry-oriented perspective on learning contrasts rather sharply with that of traditional instruction, with its focus on lecturing, memorization of scientific facts and practical work guided by teacher instruction (T. Bell, Urhahne, Schanze, & Ploetzner, 2010). This view on learning is supported by recent knowledge on how people/students learn (National Research Council, 2000), which emphasizes that it is not the activities in themself that are important for development of conceptual understanding, it is that students are cognitively active during the activities.

The role of the science module developed in this study, Global Climate Exchange, is to scaffold students' activities and the teacher's role is to guide and support the students in their learning process. The overall objective is to enhance the individual students' understanding, but the method for students to achieve this, is through cooperation and collaboration with peers. This educational principle of inquiry-based science teaching (focus on individual learning) is derived from a social constructivist perspective of learning. This theoretical perspective interprets scientific knowledge as being socially constructed, and learning as a social process of knowledge construction involving both individual and collaborative activities (Driver et al., 1994).

To scaffold the inquiry-based science teaching in Global Climate Exchange we have followed guidelines building on the prior work on "knowledge community and inquiry (KCI) in the classroom" (Slotta & Najafi, 2010). Among the design principles for KCI science curricula are to enable students to establish and develop a shared knowledge-base, to enable collaborative inquiry between teachers, designers and researchers, to use technology to scaffold students work and to address learning goals for assessment (Najafi & Slotta, 2010).

The 5E Instructional Model (Bybee et al., 2006) has also inspired this work. According to the 5E Instructional Model the purpose of inquiry-based activities are specified into the following phases: *Engagement, Exploration, Explanation, Elaboration* and *Evaluation*. These guidelines define the purpose of inquiry-based tasks and materials in Global Climate Exchange as that of getting the students to be engaged in climate change topics, explore and explain issues, elaborate their ideas and evaluate their own and their peers' explanations.

Activities in Engagement phase should promote students' curiosity and elicit their prior knowledge. In *Exploration* phase students engage in activities that help them use prior knowledge to generate new ideas, explore questions and possibilities. In the *Explanation* phase students' explain their understanding of concepts, and explanations from the teacher or the curriculum may guide them toward a deeper understanding. In the *Elaboration* phase students shall apply their understanding of the concepts by engaging in additional activities. The *Evaluation* phase should be an integrated part of all phases and encourages students to assess their understanding to guide their progress toward achieving the educational objectives. These phases should be considered as a cyclic pattern, where inquiry tasks often involve focus on more than one phase, but not necessary all simultaneously. The 5E Instructional Model has been shown effective in guiding the design of inquiry-based science modules and an effective approach to learning (ibid.; Lawson, 1995).

2.5 Peer collaboration

Engaging students in inquiry-based science teaching often involves some form of *peer collaboration* (T. Bell et al., 2010; Gerard et al., 2009; Hoadley, 2004) and is the main focus of this thesis. The social process of knowledge construction in peer collaboration refers to students working together in activities that contain both *cooperative* (i.e. asynchronous) and *collaborative* (i.e. synchronous) features. In cooperative work, students work individually before they contribute their results to their group product (Stahl, Koschmann, & Suthers, 2006). Cooperative work often happens asynchronously, and seldom includes collaborative communication. On the other hand, in collaborative work students work together, conduct activities and construct knowledge (Dillenbourg, 1999; Duit & Treagust, 1998; Hakkarainen, 2003). In collaborative activities students communicate with each other to exchange ideas.

Because it stimulates individual reflection and collaborative learning, the combination of both cooperative and collaborative features in peer collaboration has been proven to be effective to consolidate conceptual understanding (Tao, 1999). Yet, peer collaboration does not automatically improve conceptual understanding (Dillenbourg, 1999). The cognitive value seems to be reliant on two main factors: discrepancy and active participation (Fawcett & Garton, 2005; Howe, Tolmie, Greer, & Mackenzie, 1995).

Discrepancy refers to interactions between peers that either have unequal competences or different knowledge and because cognitive conflicts and connections between old and new knowledge occur, this can improve conceptual understanding (ibid.; Driver et al., 1994). Because students have different knowledge bases due to cultural and geographic differences, one way to achieve discrepancy is through international peer collaboration. The benefit of interactions between international peers is that students get access to a greater diversity of ideas and global perspectives on science issues than when limited to interactions with national or local peers (Slotta & Jorde, 2010; Slotta, Jorde, & Holmes, 2005). Still, discrepancy does not in itself enhance students' conceptual understanding if they are not active participants involved in the task by using verbal (talking, writing) communication (Duschl & Osborne, 2002; Erduran & Jiménez-Aleixandre, 2007; Mortimer & Scott, 2003). When collaborating, students both interact, "interthink" (Mercer, 2000) and use communication as a tool for learning.

The number of student utterances (Garton, 2007) as well as quality of utterances (Mercer, 1994, 2004) have been associated with students' conceptual development. One way to analyze and evaluate students' collaborative communication skills is to explore content and interactions between peers. In my study I have used the framework of Mercer (1995) to define communication as *Disputational, Cumulative or Exploratory*. This will be further explained and elaborated in chapter 3 and in Paper III.

3 METHODS

In this chapter I first describe the instructional activity; science module Global Climate Exchange which was designed by Professor J.D. Slotta at Toronto University in Canada and further developed in collaboration with the author during this PhD study. Section 3.2 gives an overview of the complete data used in the analyses in this thesis; section 3.3 accounts for the analytical methods used in Paper II to analyze students' conceptual understanding; Paper III analyses students' cooperative work and collaborative communication in peer collaboration. The method applied in Paper II is more thoroughly described and exemplified in the methodological Paper I. In section 3.4 the research credibility of this study, in terms of validity, reliability and transferability, is discussed.

3.1 Instructional activity: the science module Global Climate Exchange

To support international peer collaboration, we designed and constructed the science module Global Climate Exchange, using the open source Web-based application Drupal. The module was designed as a scaffolding wiki, in other words an online knowledge community where students were scaffolded through activities, by tasks given by the designers and the teacher, to explore and discuss climate change issues. When implemented, the Global Climate Exchange wiki was without any content and it was gradually filled up with the students' contributions as they were guided through the activities.

Science modules can be an effective support in the development of students' understanding of complex topics such as global climate change (Svihla & Linn, 2012). The scaffolding design of Global Climate Exchange activities follows guidelines for "knowledge community and inquiry in the classroom" (Najafi & Slotta, 2010; Slotta & Najafi, 2010). The scaffolding design implies that there was a balance between guidance and freedom emphasized to assure students having ample opportunities to be involved in their learning process, while allowing teachers ample opportunity to guide the process towards educational learning objectives (ibid.; Peters & Slotta, 2010). In this study, climate change was taught to upper secondary students (age 16-19) in four countries (Canada, China, Norway and Sweden) as part of their science education and the emphasis in the activities was on the science of climate change *(natural environment).* However since climate change is a socio-scientific issue, *social environment* and *economy* were also included in both the design of the activities and by the students themselves, mainly in the discussion activities.

The learning objective of the Global Climate Exchange activities was to enhance students' *ecological* and *global* conceptual understanding of climate change so that they will be able to make informed personal decisions, contributing to a sustainable future. Explicitly this means that we intended to develop students' understanding of causalities e.g. causes, consequences, mechanisms and adaptations to changes, on a local and a global levels in the climate system.

The goal was to enhance the individual students' understanding, and the method for students to achieve this was through cooperation and collaboration with international peers. By focusing on climate change issues from different geographical perspectives (e.g. Scandinavian: lots of coastline, high in the arctic; China: lots of land mass, more equatorial; Canada: somewhere in between), students were able to see the global aspects of these issues and develop a more coherent understanding of causalities. Through the peer collaboration students could get access to a diversity of ideas and perspectives on climate change issues. They also could make their own ideas explicit and comparable to those of their peers. Both of these aspects can help students to examine their own perspectives and ideas, evaluate alternative conceptions and hence develop and broaden their understanding (Driver et al., 1994; Duschl & Gitomer, 1991).

In Global Climate Exchange students were guided to collaborate with peers through four different activities: *Brainstorm activity, Issue activity, Discussions activity* and *Chat activity.* These activities contained both cooperative and collaborative features.

Brainstorm activity *(engage)*

The first activity in Global Climate Exchange was a brainstorm activity, where the students' task was to identify national climate change issues, add these to a Google Map developed specifically for this activity and describe the issues on a brainstorm page. The focus of this activity was to *engage* students in thinking about climate change topics by promoting their curiosity and eliciting their prior knowledge. Through this activity the students started to communicate national and local climate change issues to peers. After finishing this activity the students' work was examined by teachers and researchers to identify global issues that were relevant for further elaboration in the subsequent activities.

Issue activity *(explore and explain)*

After the brainstorm activity, each student had to join a group related to one climate change issue they chose to investigate further. The task in the issue activity was to search for information, collect and interpret evidence about the climate change issue, and to formulate explanations. More specific, they were asked to describe the issue, give relevant examples from their own countries and explain the science related to the issue. The objective of the issue activity was to engage students in *exploring* and *explaining* climate change issues. Through exploration students can use their prior knowledge to generate new ideas, explore questions and through explanation the students' can clarify their understanding of concepts and ideas.

Discussions activity *(explain, elaborate and evaluate)*

Still working in their groups from the issue activity the students were introduced to a discussion activity. The discussions were initiated by questions posed by the designers and teachers about climate change topics, and students answered these questions, raised their own questions and commented on other students' contributions. The first main question was: "What is "Global" in Global Climate Change?. This was guided by following questions: "How are the problems in our countries inter-related?" and "How does the climate change in one part of the world affect other parts of the world? ". The next main question was: "How can changes in your lifestyle improve climate change?" guided by "After reading about the climate change issues in the other countries, how does your lifestyle influence climate change?" The following questions were: "What could be done?", "What has been done?", and "What might happen if we do nothing?" within these areas: Government or remediation program, policies, personal lifestyle, influence on national environment and influence on global environment. The discussion activity focuses on *explanation, elaboration* and *evaluation*, where students explain and apply prior and new knowledge to a new context. These processes are guiding them towards deeper and broader understanding of climate change issues.

Chat room *(engage and explain)*

Embedded in Global Climate Exchange there also was the option for students to, at any time, create a chat room. There was no guidance provided for the use of chat rooms in Global Climate Exchange, except for some ethical rules, which were monitored by researchers and teachers in each country. The chat rooms allowed students to collaborate on tasks, get technical or instructional help, or simply have informal communication with peers.

Evaluation was an integrated and continuous part of all activities. By writing down their explanations and ideas within Global Climate Exchange, the students made their thinking visible to themselves and others. This process could help them to assess their own understanding and perhaps guide them towards a better *ecological* and *global* conceptual understanding of climate change.

3.2 Data collection

In 2009 we engaged three cohorts of students (age 15-17) from Canada (n=10), China (n=12) and Sweden (n=16) to collaborate for six weeks in Global Climate Exchange. After this first year, we improved the science module based on feedback from students and teachers and our personal experiences. In 2010, we engaged four new cohorts of students (age 16-19) from Canada (n=30), China (n=46), Sweden (n=52) and Norway (n=29) (in total, 157) to collaborate for six weeks in Global Climate Exchange. Schools, teachers and students were recruited based on responses to an invitation to participate in the Global Climate Exchange (Appendix II). In each location, one science teacher and one science education researcher coordinated the student activities.

Data used for analyses in this study was derived from the second year of implementation (2010). The total data set consists of students' written text, wiki logs, pre- and post – questionnaires and pre- and post-interviews. Task guiding students' activities, questionnaire, and interview guide used to collect the data may be found in the Appendix III - V. The project is registered and approved by the Norwegian Social Science Data Services (NSD), with regard to data gathering, data analysis, and issues of methodology, privacy and research ethics (Appendix I).

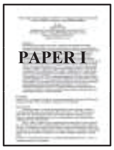
The *written text* was produced by the 157 students over a period of six weeks in the Global Climate Exchange wiki. These contributions were logged by coding them with unique usernames and time, thus allowing us to follow each student's engagement and development over time. The pre- and post-questionnaires were from the same 157 students. The pre-questionnaire was administered before starting in Global Climate Exchange and the post-questionnaire approximately two weeks after completion. The questionnaire included a mixture of closed and open-ended questions aiming to collect background information (gender, interests etc.), the students' ideas of climate change and to evaluate the Global Climate Exchange science module from the students' point of view. The *pre- and post-interviews* were limited to the Norwegian students. Each interview lasted between 15 and 25 minutes and was conducted by the author and an assistant researcher. All interviews were recorded and transcribed.

In the analysis, ten of the original 29 Norwegian students were excluded due to significant lack of data (i.e. because of limited participation in the online environment due to absence from school).

Participation in the Global Climate Exchange required students to communicate in English. However, students were allowed to use all types of supporting tools to write and translate their contributions. In the post survey less than 15% of the students considered their English language ability to be a barrier for their contributions and degree of participation in Global Climate Exchange. Language has been considered as an asset allowing students to communicate across nationalities rather than a factor impacting negatively on the results of this study.

3.3 Data selections and analytic methods

Selection of data and analytic methods were chosen according to the proposed research question (s) in Papers I, II and III, and guided by the theoretical background for the studies.



PAPER I: The Ecological Understanding Tool (ECUT): Assessing General and Subject Specific Aspects of Students' Ecological Conceptual Understanding.

Research questions:

- *How can students' ecological conceptual understanding be defined and assessed?*
- *How can the development of students' ecological conceptual understanding be evaluated?*

Paper I is a methodological Paper the Ecological Understanding Tool (ECUT) is presented and described. ECUT is an analytic assessment tool developed during this PhD study. It is based on the Structure of the Observed Learning Outcomes (SOLO) Taxonomy (Biggs, 1979; Biggs & Collis, 1982) and the Taxonomy of Causal Models (Grotzer & Perkins, 2000). The tool evolved through an iterative process of defining ecological conceptual understanding, inquiring and evaluating taxonomies and other analytic tools used in both science education research and for analyzing upper secondary students' explanations of climate change issues.

Defining ecological conceptual understanding

The term "*ecological conceptual understanding*" was defined through reviewing and evaluating the term in the literature of science and science education research. "*Conceptual understanding"* is used referring to the *general* aspects of students' conceptual understanding i.e. how they organize *"knowledge around core concepts"*(National Research Council, 2005), and "*ecological understanding"* referring to the *subject specific* aspect of students' understanding i.e. how they understand the relationship (patterns of interaction) between biotic and abiotic factors in ecosystems. Hence "*ecological conceptual understanding*" was defined as *"students' ability to explain how dynamics of relationships and processes among biotic and abiotic components can shape, influence and change an ecosystem"* (Begon et al., 1996; Campbell et al., 1999; Pickett, Kolasa, & Jones, 2007).

Constructing the Ecological Understanding Tool (ECUT)

To construct the Ecological Understanding Tool (ECUT), a number taxonomies and analytic tools were applied to analyze students' explanations of ecology and climate change issues. During this process it was discovered that the Structure of the Observed Learning Outcomes (SOLO) Taxonomy (Biggs & Collis, 1982) made it possible to capture *general aspects* of students' understandings of concepts by capturing how they organize their explanation. On the other hand, the Taxonomy of Causal Models (Grotzer & Perkins, 2000) made it possible to capture *subject specific* aspects of students' ecological conceptual understanding in terms of how they explain causalities. Based on these two taxonomies, *Organization* and *Causalities* were used as variables and integrated in ECUT. In the elaborative coding process in ECUT three explicit variables (*concepts*, *link quality* and *perspectives)* were derived, mainly from the work of Rebich and Gautier (2005) who used concept mapping to reveal students' prior knowledge and conceptual change of global climate change and similarly integrated into ECUT. The variables were then divided into two analytic dimensions. The first dimension consists of the three variables: 1) relation of concepts *(concepts),* 2) link quality between concepts *(link quality)* and 3) number of perspectives of and issue/phenomena explained *(perspectives).* Based on first dimension the focus in the second dimension is: 1) the structural organization of knowledge *(organization),* (derived from SOLO) and 2) patterns of interaction between causes and effects *(causalities)* (derived from the Taxonomy of Causal Models).

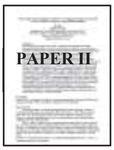
Applying the Ecological Understanding Tool (ECUT) to analysis

The data selected for this study consisted of the Norwegian students' written texts in the issue activity. One initial and eighteen final explanations of climate change issues were analyzed. The students' written texts were imported into the data programme NVivo, and analyzed in the following four steps:

In the first step, the variables from the first dimension (*scientific concepts, links and perspectives*) in students' written explanations were identified and coded. Secondly, student explanations were categorized in concepts and links and converted into concepts maps, a valuable tool for visualizing student development (Kinchin, Hay, & Adams, 2000; Rye & Rubba, 2002). To construct concept maps the free online software text2mind was used. Concept maps are used in Ecological Understanding Tool (ECUT) for two reasons; they visualize the structural organization of student explanations, and provide an illustration of the developmental progress when students elaborate their explanation. Both of these characteristics make concept maps an important and supportive tool in the analysis of ecological conceptual understanding. Third, based on coding and concepts maps, variables in the second dimension (*organization and causalities*) were coded. Finally, students' ecological conceptual understanding was estimated and assigned a level, based on the overall impression from coding at the first and second dimension. This leveling followed a five point scale, ranging from level 1 (lowest level of ecological conceptual understanding) to level 5 (high level of ecological conceptual understanding).

Evaluating the Ecological Understanding Tool (ECUT)

Finally to test for inter-reliability, a coding comparison query was performed in NVivo and the reliability was calculated in two measurements: percentage agreement and the Cohen's Kappa coefficient.



PAPER II: "Climate change is global, not local" – A study of the Development of Students' Ecological and Global Understanding of Climate Change.

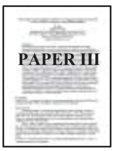
Research questions:

- *What is the impact of Global Climate Exchange on Norwegian upper secondary students' ecological and global conceptual understanding of climate change?*
- *Are there any patterns in students' international collaboration activities that correlate with their ecological and global conceptual understanding of climate change?*

In Paper II we explored the impact of participation in Global Climate Exchange on the Norwegian students' *ecological* conceptual understanding (understanding of complex causalities) and *global* conceptual understanding (understanding of long distance causalities) of climate change. The data selected for analysis in this Paper included *written texts* produced by nineteen Norwegian students over a period of six weeks in the Global Climate Exchange wiki and *responses from post - questionnaires and - interviews* from the same nineteen students.

Analyzing ecological and global conceptual understanding

To analyse students' *ecological* conceptual understanding we used the Ecological Understanding Tool (ECUT) and followed the analytic procedure as previously described in Paper I. To analyze the students' *global* conceptual understanding we used a qualitative approach. First we defined *global* understanding as the ability to identify cause-effect patterns over long distances, which was followed by exploring the data to find evidence for students' understanding. Based on our findings we estimated students' global understandings on a 3 level scale: lacking, intermediate and high. Finally, we calculated Pearson's correlations to investigate if there were any correlations between students' *ecological* and *global* understandings and their quantitative activity at the Global Climate Exchange wiki. Calculations were supported by Microsoft Excel.



PAPER III: Global Climate Exchange – Peer collaboration in a "global classroom"

Research question:

- *How does "Global Climate Exchange" allow students to cooperate and collaborate, and how do these collaborations promote learning?*

In Paper III we have looked further into the details of the peer collaboration in Global Climate Exchange by investigating the opportunities students were given to cooperate and collaborate and how these promoted learning. The data selected for this study was written texts, produced in a period of six weeks from the entire population (n = 157) who participated in the Global Climate Exchange 2010.

The data was qualitatively explored through the following analytic steps:
Students' contributions in each of the four Global Climate Exchange activities were examined. If peer interaction was evident and had a formal aim (e.g. related to the topic studied), we explored whether peer interactions were international (included peers from more than one country) or national (peers from one country only). Secondly, these peer interactions were coded if contributions were *cooperative* or *collaborative*. *Cooperative* work was when students worked individually before they contributed their results to their group product (Stahl et al., 2006). *Collaborative* work was when students were working together, communicating with each other, performing activities and constructing knowledge (Dillenbourg, 1999; Duit & Treagust, 1998; Hakkarainen, 2003). C*ollaborative* work was then further coded as *Disputational, Cumulative* or *Exploratory* communication using the framework of Mercer (1995):

> *Disputational communication* is dominated by sequences were students ask questions, agree or disagree, without further explanation or reason for their opinions. This kind of communication included questions like: *"Should all plastic be banned, you mean? What about our bottle used for water?"* or utterances such as *"I totally agree with you"* and *"I don't agree with you at all"*. Apparently the students have read what others have written, but it is uncertain how well these contributions are an indication of reflection and understanding.
>
> *Cumulative communication,* is characterized by positive but uncritical elaborations. The students add on information; in some cases there is no evidence that the students read and evaluate other students' statements before adding their own ideas and elaborations. An example of cumulative communication is*: "In Norway we are encouraged to use public transportation instead of cars, but today it might be a bit expensive for students and for people with low income."*

Exploratory communication is characterized by explanations and agreement or/and disagreement, which are elaborated and justified. For example: *"I agree with Bodil, sure this is a problem but it's not as serious as all of the other environmental problems (...)"* and *"I don't totally agree. Even though we set up the price, there are still some rich people continuing to use their car"*. In these contributions it is evident that the students have read and evaluated the statements from other students before making up their minds and adding their own ideas and elaborations.

3.4 Research credibility

The research credibility of my study concerns validity and reliability (Shadish, Cook, & Campbell, 2002) of my research methods. When designing and developing the science module Global Climate Exchange we used Design Based Research (T. Anderson & Shattuck, 2012; Linn, Davis, & Bell, 2004, pp. 73 - 85). This implied collaboration between designers, researchers and teachers where development of the Global Climate Exchange module was informed by evaluation in practice. This approach made it possible to conduct formative research to test and refine the educational design based on principles derived from the research.

During the research I have applied mixed methods (Bergman, 2008) by combining qualitative analysis of students' written text, questionnaires and interviews with and quantitative analysis of wiki logs.

Furthermore, in analysis of conceptual understanding, variables (concepts, link quality and perspectives) were identified and quantified from qualitative data (students' written text, questionnaires and interviews). These outcomes were converted into numerical levels (ranging from low to high understanding) and in some cases correlated to quantitative data (wiki logs). Analysis of interactions and communication in student peer collaboration has been entirely qualitative using students' written texts.

Validity

In this study I have made several considerations with regard to validity. The validity of qualitative research can be seen as: the extent to which an account accurately represents the social phenomena to which it refers to (Hammersley, 2008). When evaluating the validity of my study, I have judged if the data I have collected was relevant and appropriate for my research questions and to which extent these data could support my conclusions.

The students' written explanations and utterances in the discussion were the data foundation for analysing the students' communicative peer collaboration. The benefit from using written data instead of oral data is that students can act asynchronically. They have time to think and reflect before acting. Writing also gives students who feel uncomfortable about speaking in an oral setting opportunities to express themselves (Dawson & Taylor, 1998). To assess students' conceptual understanding, students' written explanations of climate change issues (from wiki and questionnaires) was combined with their oral explanations (interviews). I am aware that students' explanations are the observable action expressing their understanding and not their actually understanding (Gorin, 2006). However, the benefit from the data triangulation can increase the validity of data, because diverse data can give complementary information and hence a more "correct picture" of students' understanding (Silverman, 2009, p. 294).

Reliability

Reliability refers to the consistency of a measure and to the degree of documentation of the research procedures (Cook, Campbell, & Day, 1979; Silverman, 2009). Reliability concerns judgment about analyses from which conclusions are drawn. During my research I experienced many qualitative analyses as a bit blurry, primarily based on abstract theories without a scaffolding framework for the analytic process. This characteristic has often been the origin to criticism of validity in qualitative research (Hammersley, 2008). The choice between the structured and less structured framework for the analytic process, is a balance in qualitative research. It is to be considered because one often aims at researching rather complex contexts where explicit variables can be problematic and less appropriate to isolate.

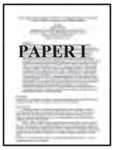
In my study I have developed the analytic tool ECUT. In ECUT explicit variables are identified and measured to draw inferences of students' conceptual understanding. These variables were carefully selected from other taxonomies (Biggs & Collis, 1982; Grotzer & Perkins, 2000) and supported by literature of conceptual understanding (Boulton-Lewis, 1995; Brabrand & Dahl, 2009; Chan, Tsui, Chan, & Hong, 2002). To test for inter-reliability in ECUT, coding on 50% of the explanations was performed a second time by the same coder (me), with 11 months interval between coding. A coding comparison query was performed to measure inter-rater reliability between the codings. The reliability was calculated in two measurements: percentage agreement and the Cohen's Kappa coefficient. The results indicated moderate to high inter-reliability of ECUT. In addition to make my qualitative analysis rather concrete, the use of ECUT has also increased the transparency of my study.

Generalization

The results from this study are limited to a number of students that may or may not be representative for a random population of students. The fact that the participants are non-randomized disqualifies this study from being generalizable under the premises for quantitative research (Shadish et al., 2002, p. 341). However, in qualitative studies generalization can refer to what extend the findings within one educational setting are applicable to other educational settings (Ercikan & Roth, 2006). The objective of my study was not to draw conclusions on international peer collaboration in general work, rather to illustrate important features of international peer collaboration in relation to students' conceptual understanding. The study can contribute to generalization by discussing the results in relation to findings from studies with similar empirical settings.

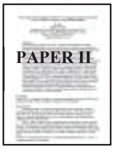
4 SUMMARY OF RESULTS

The results of my study are fully described in the three papers. In this chapter the main findings are briefly described as a preparation for the general discussion in chapter 5.



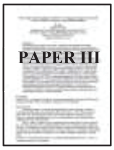
Paper I: The Ecological Understanding Tool (ECUT): Assessing general and subject specific aspects of students' ecological conceptual understanding

In Paper I the analytic assessment tool, the Ecological Understanding Tool (ECUT) is presented. Analyzing students' conceptual development from science teaching is central to evaluating and improving science education (Driver & Erickson, 1983; Duit & Treagust, 2003). However, developing analytic tools which explicitly visualize aspects of students' conceptual understanding in science is challenging and sought after. The Ecological Understanding Tool (ECUT) is based on two well-known and widely used taxonomies; the Structure of the Observed Learning Outcomes Taxonomy (SOLO) (Biggs & Collis, 1982) and the Taxonomy of Causal Models (Grotzer & Perkins, 2000). The Paper focuses on the construction and applicability of ECUT and demonstrates how ECUT can be used to analyze students' ecological conceptual understanding, and to evaluate the development of this understanding. The students' explanations of a climate change issue were analyzed according to five variables in two dimensions. Furthermore ECUT was applied to one of the student's initial and final explanations to reveal his personal development. The results from this study indicate that ECUT can capture both subject specific and general aspects of students' understanding, and that the coding has a high inter-reliability. Conclusively, ECUT appears functional as an analytic tool for assessment of students' conceptual ecological understanding, which hopefully can support future research in science education.



Paper II: "Climate change is global, not local" – A study of the Development of Students' Ecological and Global Understanding of Climate Change

This Paper reports on the development of students' ecological and global understanding of climate change from participating in Global Climate Exchange. We explored the impact on Norwegian upper secondary students' ecological conceptual understanding, understanding of complex causalities, and global conceptual understanding, understanding of long distance causalities, of climate change, from interacting with students from Canada, China and Sweden. In Paper II three analyses, including a correlation of participation patterns with conceptual understandings, are described. Our analysis of students' *ecological* conceptual understanding, shows that the majority of students were able to identify multiple or cyclic linear causalities after six weeks of peer collaboration. This indicates a relative high level of ecological conceptual understanding. During that same period, the majority of students had acquired a high understanding of long distance causalities Our correlation analysis indicates that the amount of interactions with peers could have an impact on students' personal development of conceptual understanding. Students who interact most with peers, both national and international, enhance their ecological and global understanding more than students who have fewer interactions. The results of this study indicate that international peer collaboration, if successfully supported, could enhance students' conceptual understanding of climate change.



Paper III: Global Climate Exchange – Peer collaboration in a "global classroom"

In this Paper we looked further into the details of the students' peer interactions in terms of how "Global Climate Exchange" provides opportunities for them to cooperate and collaborate, and how students utilize these opportunities. In our analysis we investigated the students' engagement in four online Global Climate Exchange activities: *brainstorm, issue, discussion* and *chat*. The study revealed that the students were given different opportunities to cooperate and collaborate in the activities. In particular the brainstorm and issue activities gave students opportunities to cooperate, whereas the discussion and the chat activity gave students opportunities for collaboration and communication. Our analysis of the collaborative communication (Mercer, 1995) revealed that exploratory communication was dominating the peer communication in the discussion activity as well as in the chat activity. Cumulative communication was second most frequent, furthermore disputational communication only occurred in the discussion activity. However, in both discussion and chat there were considerable differences between communications involving only national peers and those involving international peers. Exploratory communication was noticeably more common in communication between international peers than between national peers only, and disputational communication was only registered between national peers. The fact that exploratory communication was dominating communication involving international peers, and that disputational was absent, indicates that communication between international peers might be more beneficial than when communication is limited to national peers. This can also be a possible explanation for findings in Paper I. One reason for the more productive communication could be that students in international peer collaboration are likely to bring different knowledge to the project due to cultural and geographic differences. This provides students with access to a greater diversity of ideas and perspectives on science issues than when limited to interactions with national or local peers (Slotta & Jorde, 2010; Slotta et al., 2005). The study has shown the possibilities of how diverse peer collaboration activities might enable students to collaborate both with national and international peers and therefore support their conceptual understanding of climate change in various ways.

5 GENERAL DISCUSSION

Climate change is not local, it is global. This means that many environmental issues related to climate change are not geographically limited and hence concern humans in more than one location. There is a growing body of research indicating that today's increased climate change is caused by human activities and our modern lifestyle. Consequently, climate change awareness and attention from the entire world's population needs to be a global priority and we need to work collaboratively to attain a sustainable future. A powerful tool in this process is to develop understanding of climate change through education. Recognizing this, climate change has been included in many science curricula as a part of science education in school. However, teaching a complex and global topic as climate change is not easy. The development of the science module, Global Climate Exchange, and the research in this thesis has been driven by this challenge.

Focus has been *to explore the development of students' conceptual understanding of climate change from international peer collaboration.* This implies focus on *students' conceptual understanding and peer collaboration*. My intention, is that the results from this study can contribute to education for development of *students' conceptual understanding of climate change* by being supportive to teachers in *inquiry-based science teaching* through *international peer collaboration*.

The three Papers included in this thesis discuss various aspects of this research focus. Paper I focuses on students' conceptual understanding, Paper II on the correlations between students' conceptual understanding and Global Climate Exchange and Paper III on peer collaboration and learning. An overall finding is that international peer collaboration can enhance students' conceptual understanding of climate change but needs to be successfully supported. The results indicate that our science module, Global Climate Exchange, to some extent supports student learning, but the results also stress the importance of support from the teacher as facilitator and supervisor.

Constructive peer collaboration

Previous research concludes, that peer collaboration involving both cooperative and collaborative features can be effective to consolidate conceptual understanding (Tao, 1999). In this study we designed and implemented the science module Global Climate Exchange to support international peer collaboration. Findings in Paper III show, that Global Climate

Exchange gives students opportunities to engage in various kinds of peer collaboration: cooperative work (i.e. asynchronous) and collaborative communication (i.e. synchronous).

Findings from Paper II reveal, that students' cooperative work, usually but not always, leads to development of their conceptual understandings. Yet, our correlation analysis (also in Paper II) indicates, that the amount of interaction with peers might have an impact on students' individual development of conceptual understanding.

International versus national peers – does it matter?

Within the main subject area (sustainable development) in the current Norwegian science curriculum (Utdanningsdirektoratet, 2006) for upper secondary school, there is a focus on local and global understanding of environmental issues. It is acknowledged, that prior knowledge and connecting new knowledge to a familiar context is important to develop understanding (National Research Council, 2000; 2005). Environmental education should be related to local issues to which students can relate. However, *global understanding* requires the ability to identify cause-effect patterns over long distances and considering the Earth ecosystem as a whole. This implies, that students familiarize themselves with issues that they might not have prior knowledge about and that occur in unfamiliar contexts. Students that capitalize on cultural and geographic differences will, obviously, be familiar with different local and regional contexts and have different prior knowledge. Consequently, engaging students in *international* peer collaboration may not only give the students access to a greater diversity of ideas and perspectives on science issues, but also more direct insight in other local contexts and issues through their peers.

In Paper II we analysed students' *global understanding of climate change* (i.e. the ability to identify cause-effect patterns over long distances, considering the Earth ecosystem as a whole and perceive how climate change is affecting the entire globe) and asked if these correlated with peer interactions. Results show that interactions with international peers correlate more than interacting with national peers when looking at students' development of *global* conceptual understanding of climate change. This result indicates, that the direct insight students get in other local contexts and issues through their international peers helps them to understand the *global* in climate change.

The correlation analyses between development of students' *ecological* conceptual understanding (i.e. the ability to explain how the dynamics of relationships and processes among biotic and abiotic components can shape, influence and change an ecosystem) and number of interactions with peers in Paper II, also show that interactions with international peers are more important than national peers. In Global Climate Exchange national peers are equal to classmates where students know each other.

These results, that interactions with international peers has greater impact on students' conceptual understanding, than interactions with national peers, support the theory that peer collaboration is most successful when students experience discrepancy (ibid.; Driver et al., 1994). Discrepancy occurred in Global Climate Exchange as a result of students bringing different knowledge to the international peer collaboration due to cultural and geographic differences (Slotta & Jorde, 2010). It is hence reasonable to assume, that discrepancy between international peers promotes students' conceptual understanding.

Another explanation of students' development of *conceptual understanding* could be that students make an extra effort when they collaborate with unknown peers, and this then results in a positive impact on their learning progression. Students' and teachers' comments from our pilot study of Global Climate Exchange in 2009 point toward this explanation as exemplified by the following statement: *"I've made an extra effort because the other students were going to read it"* (student) and the teacher said: *"they [the students] think it's exciting when other students read and comment on their contributions, so they want to do their best. I experienced that they really study the subject in order to provide good answers".* What students and the teacher are expressing here is an important aspect of a constructive learning community. Each student has a responsibility to assure the quality of one's own work by consulting others when constructing their understandings in a domain (Engle & Conant, 2002). Also recent research shows that the quality of reflection and critical thinking in discussions correlates positively with the amount of unknown peers in a learning community (Levinson, 2012).

Quality of peer collaboration

Further investigations of the quality of the peer-interactions are provided in Paper III. Our analysis of the collaborative communication in Global Climate Exchange revealed that exploratory communication dominated peer communication, cumulative communication was the second most frequent and disputional communication almost absent. Also, most of the exploratory communication occurred when international collaboration was present and disputational communication exclusively occurred between national peers. Productive communication might well involve all three kinds of collaborative communication and can be useful for dynamic interaction between peers (Mercer, 1994). However, even though disputational communication in Global Climate Exchange contributed to collaborative interaction, these contributions were not stimulating further discussions and hence a productive learning environment. Exploratory communication, on the other hand, both reflected a combination of collaborative interaction and individual reasoning and stimulated further discussion. Exploratory communication can therefore be interpreted as the most evident indication of peer collaboration for stimulating a productive learning environment (Mercer, 1994; Mercer, Dawes, Wegerif, & Sams, 2004; Rojas-Drummond & Mercer, 2003). These results are interesting because they show, that students tend to communicate in a more exploratory way when interacting with foreign/unknown peers than with peers they know. The results support the idea that collaboration between international peers is more productive than collaboration between national peers.

What else matters?

Peer collaboration does not automatically improve conceptual understanding (Dillenbourg, 1999). In addition to discrepancy, active participation is a crucial factor to ensure a cognitive value of peer collaboration. This is supported by our findings in Paper II. Correlation analysis show that students who advance their conceptual understanding have on average twice as many activity entries at the online Global Climate Exchange forum compared to those who did not advance.

Students' construction of knowledge is an individual, internally driven process, which requires personal commitment. Research on how students learn stresses that: 1) new knowledge must be connected to prior knowledge and 2) students must make personal sense of new knowledge for it to influence understanding in a meaningful way (National Research Council, 2005; Howe et al., 1995). In Global Climate Exchange we tried to *engage* the students in several ways. In the brainstorm activity students could elicit their prior knowledge to describe national climate change issues and several questions in the discussion activity were linked to their personal lifestyle e.g. *"How can changes in your lifestyle improve climate change?"* and *"What could be done – personal lifestyle?"* and *"What might happen if we do nothing - what will be the consequences to your personal* *life?"*. The international dimension gave students opportunities to get to know foreign students and to learn about their lives and experiences.

Our analysis revealed that there were great variations in how often each student participated in the Global Climate Exchange and how much work they contributed. We did not explore the reason for this variation, but one explanation can be that some students felt their contributions intrusive or redundant. In the study from Levinson (2012) students who did not contribute to the peer collaboration justify this with comments like *"I don't like imposing my views on others" or "people have already said what I wanted to say"*.

The challenges

According to Anderson (2002) one of the great challenges of inquiry activities is that students' must be active, engaged learners who take responsibility for their own learning. In designing Global Climate Exchange we were aware of this challenge and constructed tasks which should help students take such responsibility. We also observed that students who managed to take such responsibility (i.e. interacting frequently with peers, with a high number of entries) benefited the most, concerning the development of their conceptual understanding of climate change.

Global Climate Exchange is not constructed to stand-alone in the science classroom. It is important to note that although the Global Climate Exchange module was directed towards students interacting guided by a web based environment, the teacher is an important part of the learning environment, there to encourage and motivate to get students engaged. The importance of the teacher in web-based inquiry environments (Furberg, 2010), and in inquiry-based science teaching (van der Valk & de Jong, 2009) is nothing new, but often an under-researched topic (Mercer, 1994). Mercer (ibid.) suggests that the contribution of a teacher in "scaffolding" students' peer collaboration supported by computers can be crucial for determining the educational quality. Such, a science module is not meant to replace other teaching methods but to complement classroom activities and hence enrich the "local classroom" with a "global dimension".

Implications for science teaching

In Paper I, I demonstrate how ECUT can be applied to assess upper secondary students' ecological conceptual understanding. Even though the Ecological Understanding Tool (ECUT) was constructed as an assessment tool for analysis in science education research, I also see the possibilities for teachers to use the tool to *support the development of their students' conceptual understanding.* The variables in ECUT capture diverse aspects of students' conceptual understanding and can enhance the awareness of both students and teachers of what explicitly is meant by *ecological conceptual understanding*. Other researchers who investigated ecology education (e.g. Grotzer & Basca, 2003) recommend that, in order to enhance students' conceptual understanding, they require explicit instruction of the underlying causal structures. Through its five variables, ECUT embraces more than causal structures and can be used by teachers to guide their students to form more coherent explanations of environmental issues.

It can also be a supportive tool when assessing students' conceptual understanding. Visualizing the development of students' conceptual understanding, can help teachers to better develop teachings strategies that could support students' learning (Helldén, 2012). However, I do not foresee the tool as being appropriate for teachers to conduct the somewhat time-consuming steps in research analysis described in Paper I, but instead to guide them in their own assessment procedures.

Also, even though the tool might be most relevant to environmental education including ecological topics, many science topics require understanding containing the elements of "*ecological conceptual understanding*". The subject specific elements e.g. the relationship (patterns of interaction) between biotic and abiotic factors in ecosystems, can be generalized to: the relationship (patterns of interaction) between factors in a system. However, as this theory goes beyond the results from this study and appropriateness and effectiveness of such application, consequently needs to be verified in further research.

Concluding remarks

"Education is the most powerful weapon we can use to change the world"

– Nelson Mandela

In a time where we are facing one of the greatest global environmental challenges of our time, education is a way towards a sustainable future. Schreiner, Henriksen, & Hansen (2005) call for teaching suggestions and studies investigating students' understanding of climate change. The results from this study respond to these suggestions.

The results from the studies in this thesis show that giving students opportunities to collaborate with international peers can be productive for them to develop a coherent understanding of the complexity of global climate change. The results also show that a way to allow and support this development is to implement an inquiry-based science module like Global Climate Exchange, and the Ecological Understanding Tool can be applied to assess this development.

The findings are valuable for development of secondary science education, in particular when teaching global and complex topics, like climate change. Additional is the development of the assessment tool a valuable contribution for analytic work in science education research.

In conclusion I hope the results from my study can inspire and support science teachers, when educating young people to make informed personal decisions working towards a sustainable future.

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I

II

III

Appendices I-III

APPENDIX I: **Information letter and concent to teachers, students and rector**

UNIVERSITETET I OSLO

DET UTDANNINGSVITENSKAPELIGE FAKULTET

Til lærer, elever og rektor
ved Fagerborg videregående skole

Institutt for lærerutdanning og skoleutvikling
Postboks 1099 Blindern
0317 OSLO

Fysikkbygget, Østfløyen
Sem Sælands vei 24

Telefon: 22 85 50 70
Telefaks: 22 85 44 09
Vev-adr.: http://www.ils.uio.no/

Dato:

Forespørsel om deltakelse i Naturfagsprosjekt "Nettbaserte diskusjoner om globale klimaendringer"
Majken Korsager, doktorgradsstipendiat ved Institutt for Lærerutdanning og Skoleutvikling (ILS) ved Universitet i Oslo, jobber under veiledning av Doris Jorde, med å utvikle og evaluere nye undervisningsprosjekter i biologi og naturfag. Et av disse er prosjektet om globale klimaendringer. I prosjektet om globale klimaendringer bruker vi et nettbasert forum der elever fra Norge, Sverige, Kina og Canada kommuniserer omkring tema innen klima og miljø.
Vi har kontaktet ulike skoler i disse land og vi er glade for at Fagerborg Videregående skole har meldt sin interesse til å delta i prosjektet. Vi ønsker å kartlegge hvordan denne typen av undervisning fungerer i skolen gjennom å innhente informasjon fra observasjon og tilbakemelding fra lærere og elever i klasserommet. I den sammenheng ønsker vi å observere undervisningen under 6 uker våren 2010. Observasjonene skjer gjennom at undertegnede er tilstede i klasserommet samt med bruk av video- og lyd opptak. Får å få tilbakemelding fra lærer og elever ønsker vi gjennomføre intervju og spørreskjema. Intervjuene er beregnet å ta ca 30 minutter for læreren og ca 15 minutter for hver elev. Beregnet tid til spørreskjema er ca 15 minutter for hver elev.

Prosjektet er meldt inn til Personvernombudet for forskning, Norsk samfunnsvitenskabelig datatjeneste AS. All registrering, lagring og bruk blir gjort i henhold til personopplysningslovens retningslinjer. All informasjon vil selvfølgelig bli behandlet konfidensielt, og anonymisert i publikasjoner, slik at verken elever, lærere, klasse eller skole vil kunne identifiseres. Opptakene slettes og opplysningene anonymiseres når prosjektet er ferdigstilt, innen 1. april 2017.

Deltakelse i undersøkelsen er frivillig, og du kan når som helst underveis trekke deg, uten å oppgi noen grunn for dette. Innsamlede opplysninger om deg vil da bli anonymisert snarest mulig. Samtidig vil vi framheve undersøkelsen kvalitet er avhengig av at lærere og elever er villige til å åpne klasserommet for innsyn. Vi håper å oppleve at lærere og skole vil oppleve dette samarbeidet som interessant og nyttig.

Med vennlig hilsen

Majken Korsager Doktorgradsstipendiat i Naturfagsdidaktikk	Doris Jorde Professor i Naturfagsdidaktikk/ Veileder	Sølvi Lillejord Instituttleder v/ ILS

UNIVERSITETET I OSLO
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SAMTYKKE TIL DELTAKELSE I PROSJEKTET OM GLOBALE KLIMAENDRINGER

Elevens navn

- ☐ Undertegnede godtar med dette å være med i prosjektet. Undertegnede er klar over at det vil bli gjort lyd- og videoopptak i forbindelse med prosjektet.

All registrering, lagring og bruk av innsamlet materiale blir gjort i henhold til personopplysningslovens retningslinjer. Videre vil all informasjon bli anonymisert slik at verken elever, lærere, klasse eller skole vil kunne identifiseres. Forskere tilknyttet prosjektet er underlagt taushetsplikt og alle data vil bli behandlet konfidensielt. Prosjektet er meldt inn til Personvernombudet for forskning ved Norsk samfunnsvitenskapelig datatjeneste (NSD.

Deltakelse i prosjektet er frivillig og det er mulig å trekke seg når som helst før prosjektslutt uten at man må oppgi noen grunn for dette. Dersom noen trekker seg, anonymiseres innsamlede opplysninger om vedkommende snarest mulig. Opptakene slettes og opplysningene anonymiseres når prosjektet er ferdigstilt, innen 1. april 2017.

Dato Sted

Elevens underskrift

Foresattes underskrift

GLOBAL CLIMATE EXCHANGE

April 5th – May 16 2010

Welcome students and teachers from China, North America, Norway and Sweden to 6 weeks of international collaboration, online interactive discussions about the SCIENCE of global climate change.

"We are all sharing the same air and water on this planet – so bring the world into the classroom and let us discuss global climate change!"

Week 1: 5 – 11 April: Brainstorm of Issues & personal presentation

This first week will be a "brainstorm of issues." The students should use the internet and other information sources to find local/national issues about climate change. They shall choose an issue and write short abstract 5-10 sentences. This abstract shall be added to the *Google MyMap* and to the *GCE Brainstorm issues* page.

- *Google MyMap* - a shared global map that allows all the students to add "issues" to specific locations within their countries (e.g., where deforestation is happening, or coastal flooding or invasive species, etc).
- *GCE Brainstorm issues* page where students add descriptions of the issues on a wiki-like page (i.e., where everyone can just click "edit" - underneath a header for their country name)

In the first week, the students can also fill in their personal "profiles" on their account pages. *NB: Because of privacy concerns, we are not allowing photos, e-mail addresses, etc - but we thought it would be nice if they list their hobbies and interests.*

1

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Canada & China: Jim Slotta, jslotta@gmail.com
Norway & Sweden: Majken Korsager, majken.korsager@uv.uio.no

Week 2 and 3: 12 – 25 April: Collaboration on exploring an issue

During these 2 weeks shall the students explore an issue in collaboration with students from the other countries. Based on the Issue brainstorm, will around 10-15 "cross cutting issues" that are common to all countries be created. We will then create collaborative groups of students, assigning two or three students to each issue page, from each country, 8 - 12 students per issue page. The students shall collaborate with students from the other countries work in groups on an issue to find:

1. Name of Issue
2. Description of Issue
3. Evidence & examples of issue
4. The science related to issue

Week 4: 26 April- 2 May: Discussion of international aspects of climate change

This week will be an online discussion with focus on international aspects of climate change, with science emphasis. The students shall exchange knowledge, ideas and opinions about the “global” in climate change.

Week 5: 3 – 9 May: Creating a national action plan

This week will we reconvene students into "within-country" groups. This means that the students will be working with peers in their classroom focusing on a national action plan that addresses one or more of the issues that was covered within the previous two weeks.

Week 6: 10 – 16 May: Final discussion

This week will be the culminating discussion where students discuss the impact of their actions and international perspectives.

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INSTRUCTIONS TO STUDENTS

GLOBAL CLIMATE EXCHANGE

Week 14

BRAINSTORM

We are all sharing the same air and water on this planet – so bring the world into the classroom and let us discuss global climate change!"

Your tasks this week are:
1. **Answer a survey**
2. **Brainstorm to find local/national issues about climate change.**
3. **Present your self**

---

1. **Survey**

Log the GCE website: http://climate.oise.utoronto.ca/2010/ Click the link to the "survey" and answer the questions.

2. **Brainstorm to find local/national issues about climate change.**

Use the internet and other information sources to find local/national issues about climate change. Choose an issue and write a short abstract 5-10 lines. Log on to Google Maps through the GCE page. Make sure you write a small note about your issue (in English language!!), **and also make sure to note your username (from this site) at the bottom so we know who added or edited the issue!** Instructions on how to edit a page is available here. Also add your issue abstract to the brainstorm page at GCE.

3. **Present your self**

Write a short personal presentation of your self; hobbies, interest in science etc.

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GLOBAL CLIMATE EXCHANGE

Week 15-17

EXPLORE A CLIMATE CHANGE ISSUE

We are all sharing the same air and water on this planet – so bring the world into the classroom and let us discuss global climate change!"

Your tasks this week are:

1. **Choose a Climate change issue and join the issue group. Start exploring your issue in collaboration with your group and on your shared issue page**
2. **Chat- comment - ask questions**

---

1. **Climate change issue collaboration**

Use the internet and other information sources to find local, national, or global information about your issue. Add your ideas about the description of the issue, the climate change science, and any examples from your country.

5. Name of Issue
6. Description of Issue
7. Evidence & examples of issue
8. The science related to issue

Just like Wikipedia, you should try to improve on your teammates' ideas - add new sentences to their sentences, reorganize if necessary, etc. Make sure you stay in touch in the chat room so your team mates know what you are working on. Instructions on how to edit a page is available here. Remember that you as a group in collaboration has responsibility of finishing your issue page.

2. **Chat- comment - ask questions**

Use the chatroom to create a chat for your Issue team, where you can ask questions of your team mates, and to make a plan for completing the page. Work together! When creating chats, please use your issue title as the chat's title. Remember to keep language focused on the project.

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GLOBAL CLIMATE EXCHANGE

Week 18

KEEP EXPLORING YOUR ISSUE

We are all sharing the same air and water on this planet – so bring the world into the classroom and let us discuss global climate change!"

Your tasks in this week are:

1. **Keep exploring your issue in collaboration with your group and finish your issue page**
2. **Chat- comment - ask questions**

1. Keep exploring your issue in collaboration with your group and finish your issue page

Use the internet and other information sources to find local, national, or global information about your issue. Add your ideas about the description of the issue, the climate change science, and any examples from your country. Just like Wikipedia, you should try to improve on your teammates' ideas - add new sentences to their sentences, reorganize if necessary, etc. Make sure you stay in touch in the chat room so your team mates know what you are working on. Instructions on how to edit a page is available here.

Remember that you as a group in collaboration has responsibility of finishing your issue page. You need to complete the issue page to be able to work on with the task you will do next week.

2. Chat- comment - ask questions

Use the chatroom to create a chat for your Issue team, where you can ask questions of your team mates, and to make a plan for completing the page. Work together! When creating chats, please use your issue title as the chat's title. Remember to keep language focused on the project.

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GLOBAL CLIMATE EXCHANGE

Week 19

DISCUSS THE INTERNATIONAL ASPECTS OF CLIMATE CHANGE

Your tasks in this week are:

1. **To discuss the global aspects of climate change**
2. **To discuss how peoples lifestyle affect climate change**

We are all sharing the same air and water on this planet – so bring the world into the classroom and let us discuss global climate change!"

You have now been working on exploring your issue together with your issue group. The next step is to discuss the knowledge you have gained from this work in addition to the experiences your have from your own lifestyle.

This week will be an online discussion with focus on international aspects of climate change, with science emphasis. You shall exchange knowledge, ideas and opinions about the "global" in climate change. No ideas are wrong ideas, however keep focus on the task and issue.

IMPORTANT: Please reply to the comments from other students, with questions or additional ideas. You need all the information you can get from this discussion to solve the task for next week!

Discussion of international aspects of climate change

Go to the discussion page (link from the front page) and start discuss these questions:

Forum Topic 1: " What is "Global" in Global Climate Change? How are the problems in our countries inter-related? How does the climate change in one part of the world affect other parts of the world? Please reply to the comments from other students, with questions or additional ideas.

Forum Topic 2: "*After reading about the climate change issues in the other countries, how does your lifestyle influence climate change. Please reply to the comments of other students, with any questions about their lifestyles."*

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GLOBAL CLIMATE EXCHANGE

Week 20

EXPLORE THE NATIONAL ACTION PLAN

Your tasks in this week are to:

1. **Explore the national action plan that addresses the issues of global climate change in your country.**
2. **Find information and evidence to participate in the final discussion next week.**

We are all sharing the same air and water on this planet – so bring the world into the classroom and let us discuss global climate change!"

1. **Explore the national action plan that addresses the issues of global climate change in your country.**

   Use the internet to find information
   http://www.cicero.uio.no/home/

   Try to calculate your CO_2 emissions
   http://klimakalkulatoren.no/

2. **Find information and evidence to participate in the final discussion next week. The information you find shall prepare you to answer the questions below.**

- What could be done?
  - government or remediation program, policies
  - personal lifestyle
  - influence on the national environment
  - influence on the global environment
- What have been done (maybe no enough) in your country (province or state)?
  - government or remediation program, policies
  - personal lifestyle
  - influence on the national environment
  - influence on the global environment
- What might happen if we do nothing? (consequences)
  - what will be the consequences to the national/local environment
  - what will be the consequences to the global environment (specified in the other countries you collaborate with)
  - what will be the consequences to you?

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Hi, Thank you for answering this questionnaire. Your answers will be anonymous and only used in our research.

What is the name of your country?: *

- Norway
- Sweden
- Canada
- China

How old are you?: *

Which subject is easiest for you? : *

- English
- Science
- Math

select one of the subjects above

Which subject is most difficult subject for you? : *

- English
- Science
- Math

select one of the subjects above

Which subject is most interesting to you?: *

- English
- Science
- Math

select one of the subjects above

Which subject is least interesting to you? : *

- English
- Science
- Math

select one of the subjects above

What activities did you do the most during the GCE project? (select up to THREE): *

- Read in the school texts
- Talk with peers in groups
- Listen to the teacher
- Gather information from the Internet
- Watch a movie
- Write in worksheets
- Write reports
- Do experiments or observations
- Conduct interviews & surveys in school

select up to THREE

There are no problems in my country caused by climate change: *

- True
- False

-- Explain your answer:
INSERT TEXT BOX

Climate change is something new. The climate wasn't always changing.: *

- True
- False

-- Explain your answer:
INSERT TEXT BOX

Most people understand the issues of global climate change.: *

- True
- False

-- Explain your answer:
INSERT TEXT BOX

Climate change in another country far away will not affect the environment in my country.: *

- True
- False

-- Explain your answer:
INSERT TEXT BOX

If people do nothing about global climate change, the environment will not change that much in my lifetime.: *

- True
- False

-- Explain your answer:

The life of one person can affect climate change.: *

- True
- False

-- Explain your answer:

People disagree about the causes of Global climate change?

- True
- False

-- Explain your answer:

Humans can reverse global climate change.: *

- True
- False

-- Explain your answer:

What do you think is the greatest cause of global climate change? Explain why you think so: *

Give one ore more examples of a climate change problem in another country: *

Submit

Scientists disagree about the causes of Global climate change?

- True
- False

If your answer is "true"

How is it possible that scientist to arrive different conclusions when they are looking at the same data?

-- Explain

GLOBAL CLIMATE EXCHANGE

Week 14-20

Interview guide

Hi, and welcome.
My name is ….– what is your name?
I want to ask you 11 questions about the GCE project and global climate change. These questions help me understand your thoughts and opinions about this subject and they are not mean to be evaluative in any way. In other words, you are not being graded on your responses.

And please ask me to explain if there are something unclear. Okay?
Do you have any questions for me?

Okay, let's begin.

We are all sharing the same air and water on this planet – so bring the world into the classroom and let us discuss global climate change!"

STUDENT NAME:____________________________________
INTERVIEWER NAME: _____
DATE: _____ 2010

1. Pretend I know nothing about global climate change. Explain to me what this is.
2. What do you think could be causing global climate change?
3. Is there any disagreement about global climate change?
4. Do you think there is any disagreements among scientists about global climate change?
5. Pretend I know nothing about the "Global Climate Exchange" project - explain it to me.
6. Are you excited about this project or would you rather do something else?
7. What do you hope to learn during this project?
   a) Do you think you will learn more science content (like climate change and environmental science)?
   b) Do you think you will learn about cultural differences?
   c) Do you think you will improve your English skills?
8. Do you think it will be easy/challenging to communicate with students from other countries? Why or why not?
9. Do you think it is important to communicate with students from other countries about global climate change? (Why or why not?)
10. Do you think there will be any differences in the way students from other countries (Sweden/Canada/China) will talk about global

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climate change?

11. Should a high school student living in Japan be worried about a water shortage (lack of water) in Egypt? (Why or why not?)
12. A year ago, there was a newspaper article that explained that the cheapest car in the world is now being sold in India. Now, almost everybody in the country can buy a car. – Should people in Norway care about this?

Standard prompts:

- Tell me more, please.
- (repeat what the student said) is that right?
- I'm sorry, can you repeat what you said?
- Let me say it another way…
- Let me repeat the question for you…
- Well, what do ***you*** think…

Norsk samfunnsvitenskapelig datatjeneste AS
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Vår dato: 19.03.2010 Vår ref: 23724 / 2 / LMR Deres dato: Deres ref:

KVITTERING PÅ MELDING OM BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 09.02.2010. Meldingen gjelder prosjektet:

23724	*Naturfagsprosjekt "Nettbaserte diskusjoner om globale klimaendringer"*
Behandlingsansvarlig	*Universitetet i Oslo, ved institusjonens øverste leder*
Daglig ansvarlig	*Majken Korsager*

Personvernombudet har vurdert prosjektet og finner at behandlingen av personopplysninger er meldepliktig i henhold til personopplysningsloven § 31. Behandlingen tilfredsstiller kravene i personopplysningsloven.

Personvernombudets vurdering forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldeskjemaet, korrespondanse med ombudet, vedlagte prosjektvurdering - kommentarer samt personopplysningsloven/-helseregisterloven med forskrifter. Behandlingen av personopplysninger kan settes i gang.

Det gjøres oppmerksom på at det skal gis ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernombudets vurdering. Endringsmeldinger gis via et eget skjema, http://www.nsd.uib.no/personvern/forsk_stud/skjema.html. Det skal også gis melding etter tre år dersom prosjektet fortsatt pågår. Meldinger skal skje skriftlig til ombudet.

Personvernombudet har lagt ut opplysninger om prosjektet i en offentlig database, http://www.nsd.uib.no/personvern/prosjektoversikt.jsp.

Personvernombudet vil ved prosjektets avslutning, 01.04.2017, rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen

for
Bjørn Henrichsen

LMR
Linn-Merethe Rød

Kontaktperson: ~~Linn-Merethe~~ Rød tlf: 55 58 89 11
Vedlegg: Prosjektvurdering